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The use of different ensemble forecasting systems for wind power prediction on a real case in the South of Italy

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Abstract

Short-term wind power forecasting (WPF) is becoming increasingly important due to the constant growth of this renewable source. The probabilistic approach applied to WPF can be used to reduce forecast errors, giving also a useful information on the accuracy and uncertainty of a forecast. According to previous studies, the ECMWF Ensemble Prediction System (EPS) can be used as an indicator of a WPF accuracy. A statistical calibration performed on the wind speed EPS members allows to obtain a consistent ensemble spread. After that, it is possible to convert the data to wind energy: the spread calculated on wind power can be used as an accuracy predictor due to its level of correlation with the deterministic WPF error. In this presentation we investigate the performances of the new EPS on a complex terrain area. The work consists in the use of the deterministic ECMWF model in a WPF approach, followed by the application and verification of the EPS in order to estimate the forecast accuracy. We also preliminary compare these performances with the application of other ensemble prediction systems with higher resolution. It can be seen that calibration is a fundamental requirement in order to extract usable information from data. At least until the three days ahead forecast horizon the ensemble spread calculated on wind power seems to have enough correlation with the deterministic forecast error in order to be used as a predictor of accuracy.

Site and wind data description

The case study consists in a wind farm located in a complex-terrain mountain area in northern Sicily. It has 9 equal turbines for a total of 7.65 MW nominal power.
Wind and power data were provided for the period November 2010-October 2011. Wind data has been measured at hub height (50 m a.g.l.) by an anemometer located inside the park. A representative power data series was obtained averaging the values measured by the working turbines for each hour.

Deterministic wind power forecast

A WPF for the forecast horizon 0-72 hours ahead has been performed using the increased resolution (15 km) ECMWF deterministic model. A MOS technique based on the use of a feed-forward, recursive NN has been applied, using forecasted wind speed and wind direction as input and measured power as output. The NN has been trained on the first 5 months of data and then applied recursively on the remaining 7 months (test period). Statistical indexes reported in Table 1 were used as performance evaluation.
Figure 1 shows the WPF system used, Figure 2 shows the trend (0-72 hours ahead) of RMSE and MAE, both normalized on nominal power.

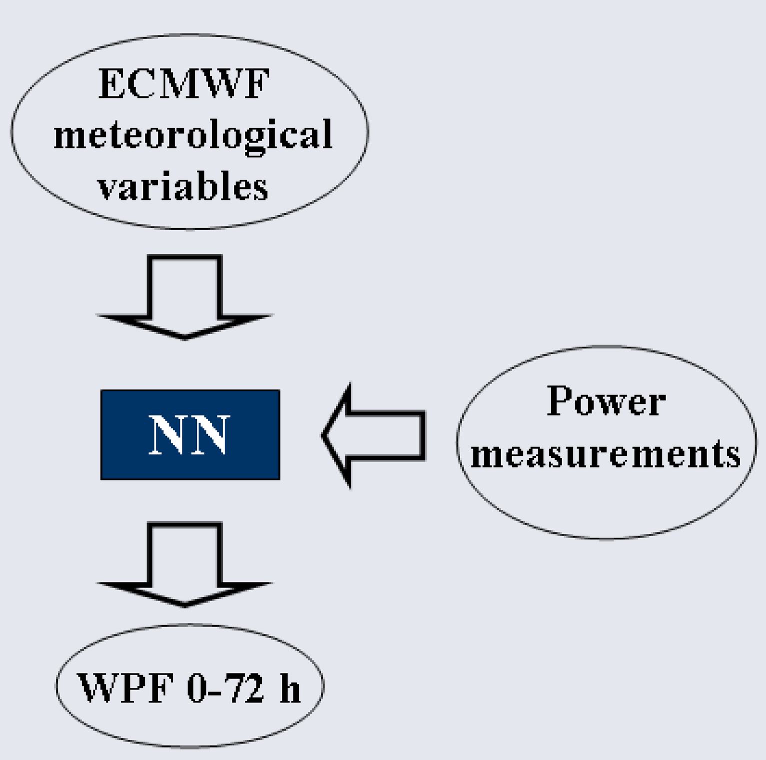

Figure 1 Deterministic WPF system

Table 1 Deterministic WPF, statistical indexes

	+ 24 h	+ 48 h	+ 72 h
RMSE/NP	14.8%	15.9%	17.3%
MAE/NP	10.4%	11.4%	12.6%
Correlation	0.78	0.75	0.69
BIAS/NP	0.02	0.02	0.03

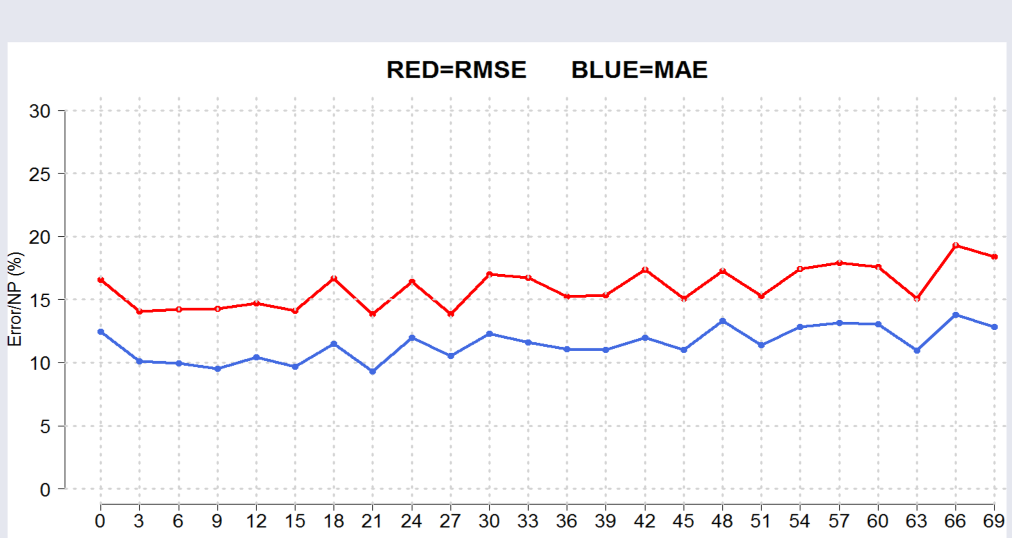

Figure 2 Deterministic WPF (ECMWF), RMSE/NP (%) and MAE/NP (%) on lead time (0-72h)

Ensemble Prediction System

The ECMWF EPS (increased resolution 32 km) is based on initial conditions perturbation (singular vectors) and stochastic model perturbations. 50 ensemble members (wind speed and wind direction) are obtained, plus a non-perturbed member. The 50+1 members are processed by a MOS (recursive NN linking the forecasted data to measured wind speed) and then statistically calibrated.

Ensemble calibration and verification

Wind speed forecasted and measured data (training period) are transformed using a logit function in order to better approximate a Gaussian distribution.

For each lead time, the ratio between RMSE, calculated between ensemble median and measured wind speed, and the mean of the standard deviation calculated on the ensemble members, allows to obtain a variance deficit coefficient. This is applied on the test period to correct the ensemble median and the variance of the transformed members, which are finally transformed back with inverse-logit function.

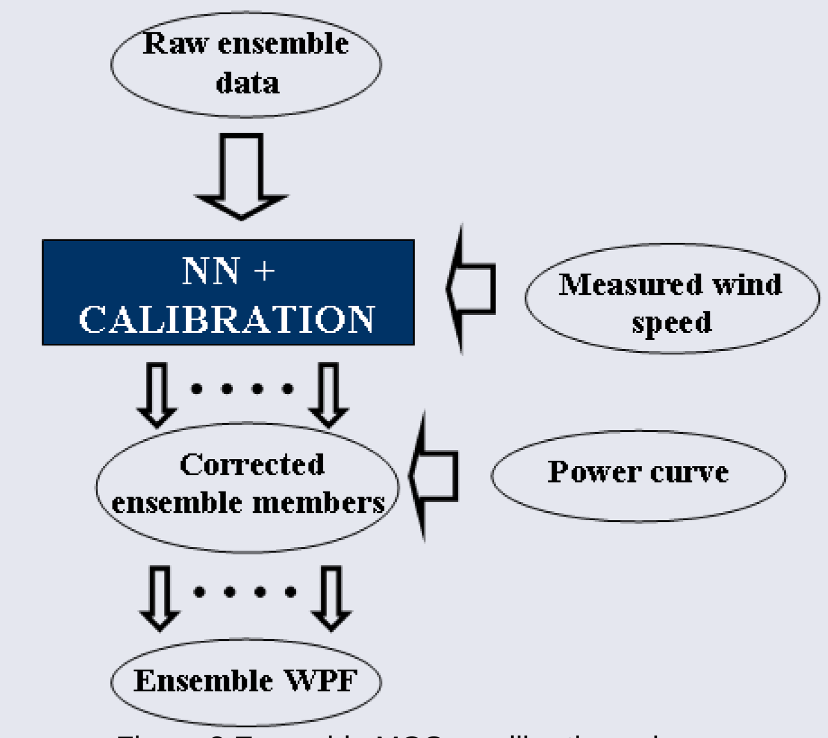

Figure 3 Ensemble MOS + calibration scheme

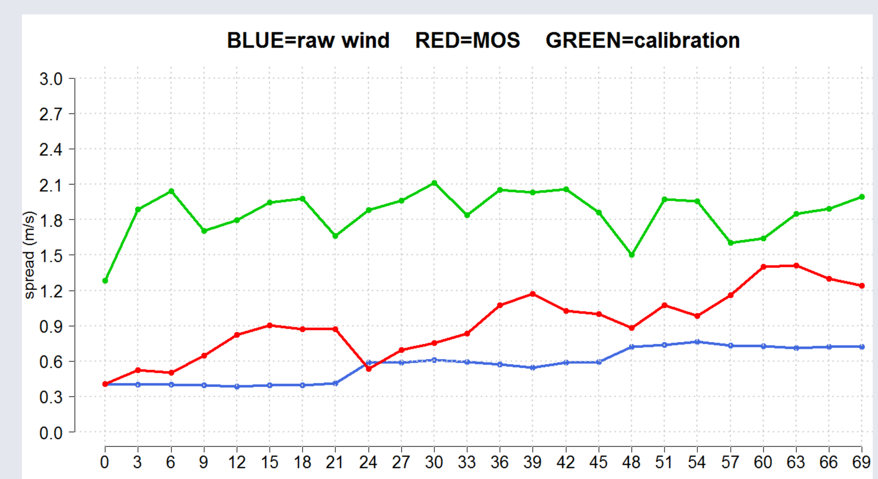

Figure 4 Ensemble spread, trend 0-72 h.

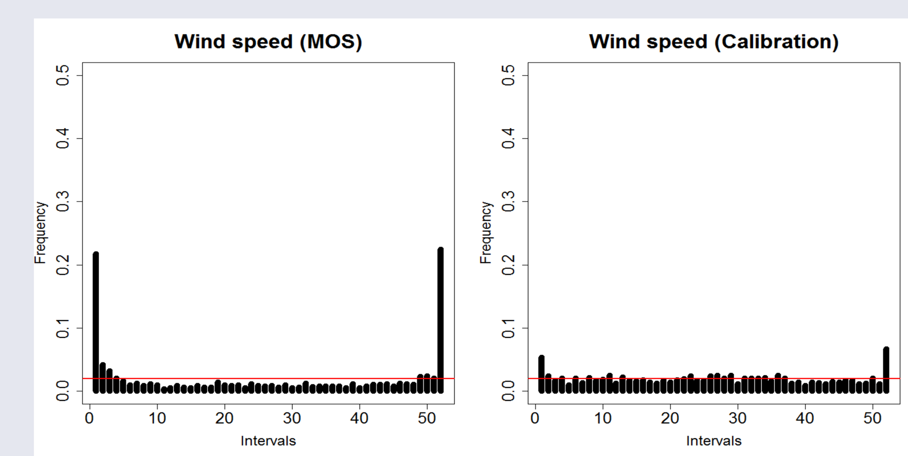

Figure 5 Rank histogram, +24 h forecast.

The calibrated members are converted to wind power using theoretical power curve provided by the turbine manufacturer, obtaining 50+1 WPF series.

WPF accuracy estimation

As in previous studies (Alessandrini et al., 2011), we calculated contingency diagrams showing the daily RMSE/NP on deterministic WPF versus the daily ensemble power spread, for the three days period. The diagonal entries are more populated than the off-diagonal cases, meaning a good level of correlation.

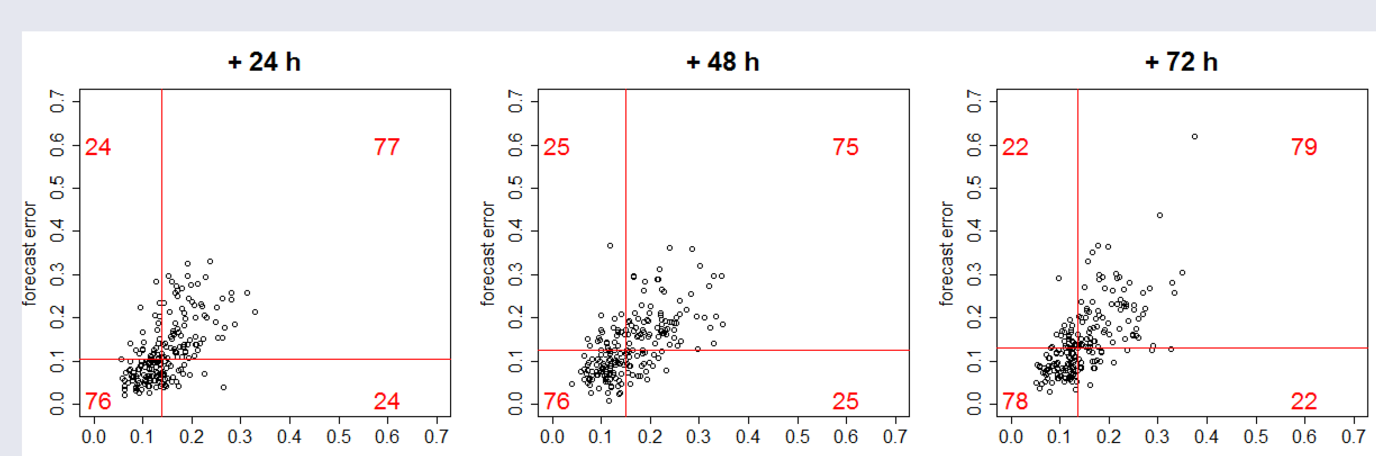

Figure 5 Contingency diagrams, daily deterministic WPF RMSE vs daily ensemble power spread

Other ensemble systems and conclusions

A preliminary comparison with EPS was conducted using data of the COSMO-LEPS ensemble model (spatial resolution 10 km, 16 members), using the same calibration procedure described above and obtaining the following results.

Table 2 Spread/error correlation

		Diagonal ratio	Correlation
EPS	*+24 h*	0.76	0.59
	+48 h	0.75	0.61
	+72 h	0.78	0.66
COSMO-LEPS	*+24 h*	0.76	0.65
	+48 h	0.70	0.53
	+72 h	0.71	0.53

Table 3 CRPS on raw, MOS, calibrated wind and power

		+ 24 h	+ 48 h	+ 72 h
EPS	*raw speed (m/s)*	3.66	3.53	3.49
	MOS speed (m/s)	1.22	1.30	1.24
	calib. speed (m/s)	1.11	1.19	1.20
	power (kWh)	67.13	68.76	72.34
COSMO-LEPS	*raw speed (m/s)*	2.70	2.50	2.50
	MOS speed (m/s)	1.21	1.21	1.31
	calib. speed (m/s)	1.13	1.17	1.28
	power (kWh)	73.71	72.35	80.70

From a first analysis, the new ensemble spread seems to have enough correlation with the deterministic error in order to be used as an accuracy predictor, at least for the first three-days forecast period. EPS shows slightly better indices increasing the forecast horizon.
COSMO-LEPS show better Continuous Ranked Probability Score on raw data, however the calibration process seems to be more effective on EPS allowing to obtain better results on corrected wind members and wind power.

References

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